

## Original Article

# Lean techniques for the improvement of patients' flow in emergency department

HY Chan, SM Lo, LLY Lee, WYL Lo, WC Yu, YF Wu, ST Ho, RSD Yeung, JTS Chan

Emergency Department, Alice Ho Miu Ling Nethersole Hospital, Hong Kong, China

Corresponding Author: HY Chan, Email: chy387@ha.org.hk

**BACKGROUND:** Emergency departments (EDs) face problems with overcrowding, access block, cost containment, and increasing demand from patients. In order to resolve these problems, there is rising interest to an approach called "lean" management. This study aims to (1) evaluate the current patient flow in ED, (2) to identify and eliminate the non-valued added process, and (3) to modify the existing process.

**METHODS:** It was a quantitative, pre- and post-lean design study with a series of lean management work implemented to improve the admission and blood result waiting time. These included structured re-design process, priority admission triage (PAT) program, enhanced communication with medical department, and use of new high sensitivity troponin-T (hsTnT) blood test. Triage waiting time, consultation waiting time, blood result time, admission waiting time, total processing time and ED length of stay were compared.

**RESULTS:** Among all the processes carried out in ED, the most time consuming processes were to wait for an admission bed (38.24 minutes; SD 66.35) and blood testing result (mean 52.73 minutes, SD 24.03). The triage waiting time and end waiting time for consultation were significantly decreased. The admission waiting time of emergency medical ward (EMW) was significantly decreased from 54.76 minutes to 24.45 minutes after implementation of PAT program ( $P<0.05$ ).

**CONCLUSION:** The application of lean management can improve the patient flow in ED. Acquiescence to the principle of lean is crucial to enhance high quality emergency care and patient satisfaction.

**KEY WORDS:** Lean; Triage; Waiting time; Patient flow; Emergency department

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## INTRODUCTION

Facing with shrinking budgets, growing volumes of patients and shortage of working staff, the need for change in health care is more apparent today.<sup>[1]</sup> One of the strategies to improve the quality and safety of health care is lean.

Lean thinking is a philosophy that focuses on eliminating waste or non-value added elements from the processes so that customers are given greater value.<sup>[2]</sup> It was originated from Toyota Production Systems and has been applied successfully in a wide variety of manufacturing industries and health care settings.<sup>[3,4]</sup> Therefore, many EDs have begun to apply lean as a way to fight against the problems of crowding, delays and medical incidents.

Lean management is a method to find out the non-

value added and time wasting processes so as to streamline the patient flow in emergency department. Value and flow are the key concepts of lean thinking.<sup>[5]</sup> Values in healthcare are the activities that enhance the quality of healthcare and promote patient well-being so as to achieve better outcome. Healthcare by nature is patient-centered outcomes that value to patient is the ultimate goal. The value is worth its while which it meets patients' needs and satisfies at a specific cost and time. Therefore, specific value is from patient's perspective and it is created by eliminating waste.<sup>[6]</sup> According to Graban,<sup>[7]</sup> waste can be defined as any activities that do not help patients or move them further from cure. One of the wastes in emergency department is the time spent for waiting, for example, the

time waiting to be seen or waiting for the next treatment. When waste is removed, patients flow smoothly and continuously.<sup>[1]</sup> This can further increase the efficiency, quality and safety of patient care.

As a result of streamline flow in healthcare processing, patient's demand is fulfilled in an effective and efficient way. All the necessary action should be done to create value flow without interruption, backflows, waiting and defects. The goal of flow is to eliminate queuing, interruption and waiting within a process.

In Western countries, the use of lean approach in managing healthcare service is common. Dickson et al,<sup>[8]</sup> Ng et al<sup>[9]</sup> and Pester et al<sup>[10]</sup> all demonstrated the success in application of lean manufacturing techniques in emergency department. King et al<sup>[11]</sup> in 2006 mentioned that the application of lean thinking in ED can improve patient flow, and thereby decreasing potential for overcrowding and access block. Besides, Holden<sup>[1]</sup> in 2011 reviewed the implementation of lean in 15 EDs in the United States, Australia and Canada. Most of them involved ED process and structural changes to improve patient care. The positive and negative patient care effects of lean have been reported.

In Hong Kong, the implementation of lean approach in ED is not a common practice. In the New Territories West Cluster Hospital, they have established a Lean Office since 2009, and a series of lean management training and workshop have been conducted. However, study on lean management is scant. In this study hospital

in 2011, lean management work has been introduced in ED in order to improve the patient flow and overcrowding environment.

This study is to evaluate the impact of lean principles on the length of patient stay in ED from the time of registration to the time of admission or discharge. In this study, the whole workflow is examined in order to (1) evaluate the current patient flow in emergency department, (2) identify and eliminate the non-value added process, and (3) modify the existing process.

## METHODS

It was a quantitative, pre- and post-lean design study conducted on all patients attending our ED within the study period. In March 2011, a preliminary assessment was done on the workflow and time sequence of each emergency procedure. The first step of the study was to draw a process flow chart that illustrates the patient pathway in ED (Figure 1). The workflows and time sequences within one day from 07:00 to 22:00 were then analyzed with the use of value-stream mapping (Figure 2). Value-stream map is a diagram that identifies all the steps in the patient pathway from order to delivery.<sup>[12]</sup> Time consumed for each step from registration to disposal was measured and documented on the value-stream map so as to quantify the amount of value-added and non-value-added time in each step. Figure 3 illustrates the important time determinants of patient flow. They are triage time, waiting time, intervention time,

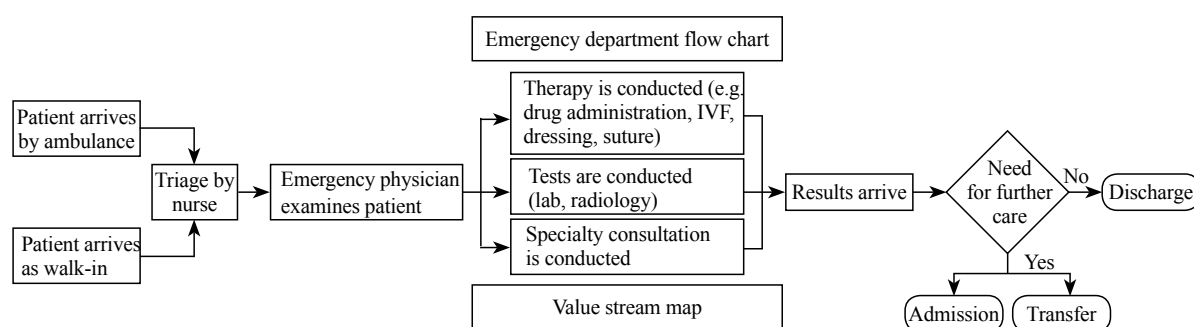


Figure 1. Emergency department logistics flow chart.

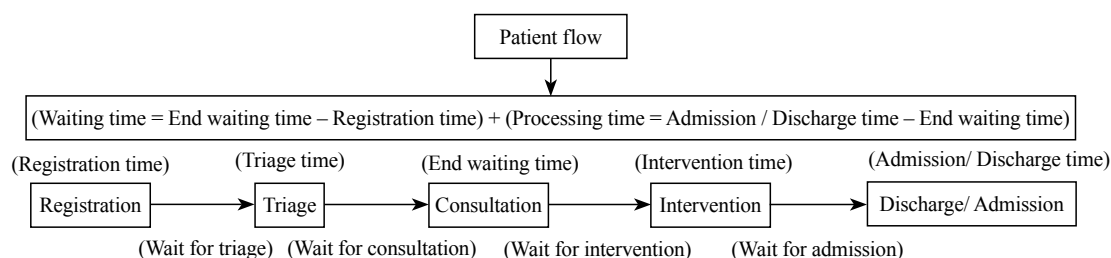
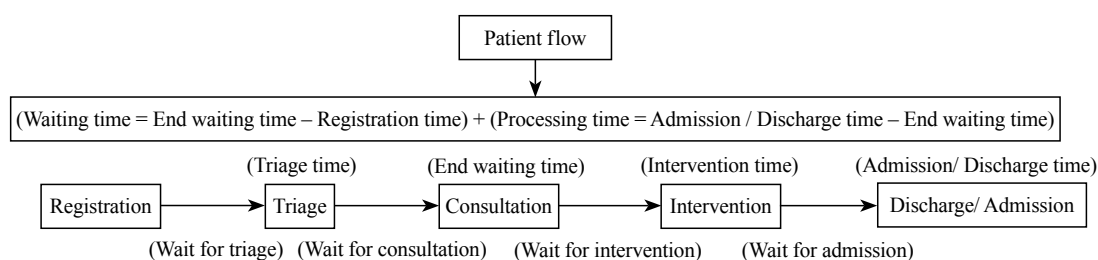


Figure 2. Value stream map.



**Figure 3.** Time determinants of patient flow in ED.

**Table 1.** Lean management work in ED

Process change	Specific example	Expected outcome
Structured re-design process	Re-engineering the layout of each consultation room	Reduce end waiting consultation time
	Inventory control and easy access in each consultation room	Reduce total processing time
	Relocate the drug cupboard	Reduce triage waiting time
	Relocate the treatment area	Reduce intervention time
	Increase the number of consultation rooms	
Priority Admission Triage Program	Re-design the signage	
	Re-construct nursing station	
	Admission screening and prioritization by emergency specialist	Reduce EMW admission waiting time
	Diverse the sub-acute medical patient to EMW	Reduce avoidable medical admission
	Centralized bed co-ordination system	Reduce admission waiting time
Communication with medical department	Report medical bed vacancy every three hours	
	Update medical bed vacancy in a timely manner	Reduce ED overcrowding
	Consult medical bed coordinator in urgent situation	
	Activate overflow system when necessary	
	Perform for patient complained of chest pain	Reduce blood result time
Cardiac Troponin-T blood test	Distinguish unstable angina patient from one with myocardial infarction without ST-segment elevation	
	High sensitivity and specificity	Reduce total processing time

ED: emergency department.

admission time and processing time.

Afterwards, from April 2011 to January 2012, a series of lean management works were implemented to improve the admission and blood result waiting time. The process was redesigned to minimize or completely eliminate the wastes. These included structured re-design process, priority admission triage (PAT) program, enhanced communication with medical department and use of new high sensitivity troponin-T (hsTnT) blood test (Table 1). Triage waiting time, consultation waiting time, blood result time, admission waiting time, total processing time and ED length of stay were compared for one week pre-lean (1<sup>st</sup> February 2011 to 7<sup>th</sup> February 2011) and one week post-lean (1<sup>st</sup> February 2012 to 7<sup>th</sup> February 2012). The data were analyzed by Statistical Package of Social Studies (SPSS) version 12.0.

## RESULTS

According to the preliminary evaluation of patient flow, we found that the most time consuming processes were to wait for an admission bed (mean 38.61 minutes, SD 64.67, maximum 305 minutes) and blood testing result (mean 52.73 minutes, SD 24.03). After lean management

**Table 2.** Comparison of time interval changes between the pre- and post-lean periods

Variables	Pre-lean mean (min)	Post-lean mean (min)	P<
Triage waiting time	3.18 (4.235)	2.63 (3.591)	0.05
Consultation waiting time	13.68 (9.731)	11.65 (7.213)	0.05
Final waiting time	16.86 (10.92)	14.28 (7.876)	0.05
Blood result time	60.01 (30.31)	76.42 (33.69)	NS
Admission waiting time	28.99 (55.60)	38.24 (66.34)	0.05
EMW admission waiting time	54.76 (80.89)	24.45 (41.63)	0.05
Processing time	100.86 (81.40)	143.41 (114.26)	0.05
Length of stay in ED	117.71 (82.28)	157.70 (113.51)	0.05

ED: emergency department; EMW: emergency medicine ward.

work since April 2011, comparison on patient flow was done on pre-lean ED attendance ( $n=313$ ) with post-lean ED attendance ( $n=281$ ). The five main diagnoses were chronic obstructive airway disease (COAD), chest pain, gastroenteritis, fever, and pneumonia.

There was no significant difference in the diagnosis, triage category and specialty in these two periods. Table 2 illustrates the comparison of time interval changes between the pre and post-lean period. The triage waiting time and end waiting time for consultation

were significantly decreased. The end waiting time was decreased from 16.85 minutes to 14.28 minutes ( $t=3.218$ ,  $P<0.05$ ) with similar staff configuration including doctors, nurses and healthcare assistants. Since the admission rate in post-lean period was significantly increased from 19% to 21% as a consequence of opening of EMW, there was a slight increase in admission waiting time, total processing time and length of stay in ED. The mean admission waiting time was 38.24 minutes (SD 66.35), mainly contributed by Medical Unit and Emergency Medicine Ward (EMW). On the other hand, the admission waiting time of EMW was significantly decreased from 54.76 minutes to 24.45 minutes after implementation of PAT program ( $P<0.05$ ). There was no significant change in the blood result time.

## DISCUSSION

The number of people attending emergency department (ED) is increasing in recent years. From April 2011 to March 2012, there is an average of 350 patients attending our ED daily, with a maximum of 463 patients attending within one day. Patients always spend at least half to two hours before discharge or admission. Most of them have to wait at each step: registration, triage by nurse, examine by physicians, blood tests, radiographs, consultations from specialists, discharge instructions and other procedures. From the patient's perspective, the processes are time-consuming and the visit is unpleasant. Therefore, understanding what patients really want and improving patient flow in ED are significant factors affecting patient satisfaction and quality of healthcare.

Our study found that structured re-design process can effectively reduce the triage waiting time and end waiting consultation time. It includes the reorganization of the layout of each consultation room with inventory control; increase of the number of consultation rooms; relocation of drug cupboard and treatment areas; reconstruction of nursing station; and redesign of signage to facilitate patient flow during each process. We demonstrated that extensive reorganization of physical layout can improve patient flow in ED. Simon et al<sup>[13]</sup> also stated that ED reorganization reduced the number of patients waiting to be seen and waiting time.

The increase in admission waiting time, total processing time and length of stay in ED can be explained by a number of factors. Patient's severity with significant co-morbidities condition would increase the disease complexity and result in complications. More diagnostic investigation and time-consuming procedure would be done before patient's admission. As a result, the medical admission waiting time, total processing time and length

of stay in ED would be lengthened. Besides, the clinical experience of emergency physician and nurse would be another confounder affecting the result. The medical admission rate was increased in the post lean period from 19% to 21%, which also contributed to the increase in admission waiting time.

Nevertheless, the hospital administrator and policy-maker try hard to solve the problem of access block and ED overcrowding. In order to increase the transparency of bed occupancy in each ward, a centralized bed coordination system was introduced. The designated bed coordinating ward would fax the bed vacancy information sheet to ED on every three hours intervals. According to the information sheet, ED has a clear picture on the number of beds available in each ward. Besides, if there was any change in bed vacancy within the three hours intervals, the ward in-charge would phone to ED to update the information. During the winter surge period, the overflow system was activated that patient with stable condition would be transferred to other unit, thus consequently bed vacancy was available for more acute patient. This policy can streamline the patient flow in ED.

Moreover, patients attend ED who deserve further medical in-patient care would stay in ED pending area till hospital beds are available. This time lag between decision for admission and the actual patient being transferred to medical ward virtually occurs in every admission especially when hospital beds are fully occupied leading to access block. This finding proves the effectiveness of PAT program in reducing the EMW admission waiting time. PAT was introduced to our ED in pace with this study so as to delineate admissions to medical ward and EMW through clinical severity stratification and to screen out the avoidable admission. The principles of PAT are based on emergency physicians who are capable of handling mild to moderate medical illnesses in EMW resulting in a shorter length of stay. It aims to diversify the sub-acute medical patient into EMW in order to alleviate the burden of medical department and ED overcrowding. This admission prioritization and screening would be performed every day by senior emergency physicians to minimize the negative impact of access block on ED service.

Although our study did not find any significant change in blood result time, the use of high sensitive troponin-T blood test clinically shortened the investigation time and thus it is more reliable for diagnostic purpose. Cardiac troponin-T is a blood test used to distinguish unstable angina from myocardial infarction without ST-segment elevation. It is more sensitive than CK-MB and may begin to rise as early as three hours after the onset of ischemia. It can also be used to detect patients with chronic skeletal

muscle disease and chronic renal disease. On the other hand, timely transport service is an important factor affecting the blood result time. ED based porter service should be increased to ensure the blood specimens that are transported to the laboratory without delay. Besides, frequent monitoring on the blood result time is necessary so as to fasten the procedure time.

Several limitations have to be considered when interpreting the results. Firstly, the data of this study may not be able to generalize to other ED due to the short study period, relative small sample size and single study site. Besides, the study attempts to evaluate a real process in the ED environment which is uncontrolled. Patients arrive at variable rate, with unpredictable needs, creating a high level of uncertainty. The attendance for emergency services may also be upsurge during long public holidays. Therefore, the state of flux of ED environment may have an influence on the findings. Moreover, selection bias that could be introduced by convenience sampling could be another limitation.

The results of this study implied that there were some areas worth improvement. The current ED porter service requires transferring patients within ED and for admission, transporting the blood specimen to the laboratory for investigation by dispatchers, and performing all the cleansing work in ED. When the porters are occupied, patient flow will be hindered with an increase of waiting time for the next process. More ED based porter service can help to provide emergency care smoothly and efficiently. Besides, electronic transfer of medical records could be developed to further decrease the time wasting for transfer of medical records from the time of registration to admission.

According to the service statistics in the year 2012, the average length of stay during in-patient hospitalization is 5.6 days. We found that 24% of the patients are short stay patients (stay <2 days). Therefore, the implementation of EMW (as a short stay unit) is another lean strategy to reduce the avoidable medical admission. In order to solve the problem of shortage of medical beds and long waiting time for admission, higher capacity EMW and bridging wards (e.g. observation ward, short stay ward) can be introduced to further elaborate the concept of PAT and improve the quality of service.

In conclusion, this study hopefully can arise ED managers to achieve robust improvements and better strategies for lean implementation. Lean management is another quality assurance method that focuses on process improvement and change management. Reducing unnecessary delays in ED is the ultimate goal to assure better patient outcome. The application of lean approach

can improve the patient flow in ED. Acquiescence to the principle of lean is crucial to enhance high quality emergency care and patient satisfaction. We believe that lean management strategies should be developed with the participation of frontline healthcare professionals in the change process.

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**Ethical approval:** The study was approved by the Medical Ethics Committee of Alice Ho Miu Ling Nethersole Hospital, Hong Kong, China.

**Conflicts of interest:** The authors state that there is no conflict of interest involving the study.

**Contributors:** Chan HY proposed the study and wrote the manuscript. All the authors read and approved the final version of the manuscript.

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